ISOTOPIC PROFILING SNOW GAGE REPORT

MT. HOOD - OREGON

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CONSERVATION OF WATER BEGINS WITH THE SNOW SURVEY

SOIL CONSERVATION SERVICE · U.S. DEPARTMENT of AGRICULTURE

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MT. HOOD, OREGON

WINTER 1971-72

ISSUED OCTOBER, 1972

by

A. J. WEBBER

State Conservationist

Prepared by

TOM A. GEORGE, Snow Survey Supervisor

and

HOWARD M. VANCE, Assistant Snow Survey Supervisor

Soil Conservation Service
1218 S. W. Washington St.
Portland, Oregon 97205

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INTRODUCTION

The Atomic Energy Commission, through contracts with the U. S. Forest Service, Berkeley, California and Aerojet Nuclear, Idaho Falls, Idaho, developed the isotopic profiling snow gage. By spring 1971 AEC determined that development was at an operational stage and decided to make three gages available to the agencies responsible for snow survey operations.

The State Office of the Soil Conservation Service, Portland, Oregon learned through the Idaho Nuclear Energy Commission that one of these gages would be tested in the deep snow country of the Columbia Basin. It was determined that a site on Mt. Hood would be ideal.

A memorandum of understanding was signed by SCS, Oregon and the Atomic Energy Commission in August 1971 to operationally test the gage at Mt. Hood, Oregon during the 1971-72 season. In addition, three other agencies, Bonneville Power Administration, Oregon Nuclear and Thermal Energy Council, and Oregon State University agreed to contribute funds toward the operation and installation costs of the gage.

SITE LOCATION

The site selected on Mt. Hood is used by the SCS to test other types of snow measuring and electronic equipment and has a good history of comparative data. A maximum depth of 220 inches of snow and a maximum water equivalent of 105.6 inches have previously been measured here. These measurements satisfied the requirement of testing in a deep, dense snowpack.

Fig. 1 shows the test site location. It is at the 5,400' elevation on the south side of Mt. Hood. The winter snowpack generally starts the last part of October, reaching a maximum near May 1, with the meltout of the pack occurring from then until late July. The Phlox Point snow course, with records of snow measurement dating back to 1937, is located at a slightly higher elevation and about one-eighth mile to the northwest.

GAGE LOCATION

The gage was located slightly west of the center of the test site (See Fig. 2). Previous measurements indicate this area gives representative data for the entire site. The test area is level and snow creep is not a problem. Comparative water equivalent was obtained from manual sampling with the Federal sampler and from other snow sensors such as snow pillows. Twenty-five feet south of the gage is a shelter that was used to house the power source and related electronic equipment. The power source was a 15-watt thermoelectric generator powered by propane.

Telephone service for data transmission and maintenance was installed and available in the shelter.

INSTALLATION

The gage was designed to operate in 24 feet of snow. The site is protected by timber but because high winds 75 to 100mph had been experienced in the general area, the gage was braced with 4" pipe to keep the long source and detector tubes from whipping about in the wind. The 26' brace poles, source and detector tubes, and base standard were constructed in Idaho Falls, Idaho and shipped to Oregon in October. All were installed and ready to operate by October 15 (Photo 1). Also at this time the pro-

pane tank was filled and ready to be hooked up to the thermoelectric generator and the telephone cables were laid up to the shelter.

The gage was to be operating by early November, however, there were some testing and construction delays. The lift unit, radioactive source, and thermoelectric generator were finally installed the last week of December. The snowpack had reached a depth of 12 feet by this time. This meant the gas line and telephone cable hookups had to be done by digging through 12 feet of snow to the ground surface (Photo 2). This was accomplished and the gage was ready to go by January 3. The first interrogation of the gage occurred on this date and the profiling gage reported 147.5" of snow and 43.5 inches water equivalent.

GAGE OPERATION

The profiling gage operated via telephone line computer command from AEC facilities in Idaho Falls, Idaho. The data was sent to Idaho Falls via the same process for computer analysis and printout. The gage information was also sent from Idaho Falls several times to the Portland SCS office via telephone line, and was printed out by teletype on hard copy and punched on paper tape. However, there was only a one to two day delay via mail, so data was mailed to Portland after the first 6 weeks of operation.

The profiling gage consists of three units; a density sensor, lift unit, and a system to condition and transmit the data. The snow density sensor is a $10M_c$ $137C_s$ source and scintillation detector suspended in two parallel access tubes twenty-six inches apart. The access tubes extend from the base standard, which is below ground, to a height greater than the depth of snow. The source and detector are stored in the base standard when the gage is not operating. On signal from Idaho Falls the lift unit

raised the source and detector up through the snowpack, taking a radiation reading every ½ inch. The source then returned to the base standard upon reaching the snow surface. The snow between the access tubes attenuates the radiation. The more water equivalent in the snow the less radiation detected. At the end of the season, when snow depths reached twenty feet, the gage was producing 480 readings of density, water equivalent, and snow depth during one profiling operation.

The gage operated satisfactorily with only one breakdown, which occurred on January 14. It was thought that icing in the lift unit caused a malfunction and repeated interrogation of the gage might start it working again. However, repeated interrogations did not solve the problem. On February 2 Aerojet Nuclear, contractor to AEC, went to Mt. Hood and found the lift cable hung up in the detector tube. They installed a new lift unit. The gage then operated properly for the remainder of the season.

By June 5 funds for telephone services for the gage had been expended and the gage was no longer operated.

Later it was determined that sometime between June 5 and 20 the telephone data set, which transmitted the data over the phone line, stopped functioning. It was removed and sent back to the manufacturer for repair.

Operating and installation expenses incurred by SCS during the 1971-72 season were as follows:

Installation Costs -

1.	Miscellaneous materials, thermoelectric generator, telephone data set, propane and tank	$1,730
2.	Labor	270

Operating Costs -

1.	Telephone communications and supplies	$2,050
2.	Labor for data plotting, analyzing and comparison; report writing and maintenance	2,200 est.
	TOTAL	$6,250

An instrument house was also furnished by the SCS.

Bonneville Power Administration contributed additional data plotting and reproduction of these plots on overlays for analyzation.

The Atomic Energy Commission furnished the profiling gage, maintenance, computer facilities, and a user training course in radiation and data interpretation. Their expenses during this first year of operation were estimated to be $15,000.

DATA AND DATA USE

The winter's accumulation of snow at the test site area set a new maximum record water equivalent reading of 110.7 inches as measured with the Federal sampler (Fig. 3). The nearby snow course read 113.0 inches water equivalent on April 28. The previous record was 1971 when 105.6 inches were measured at the snow course. An average yearly maximum for this area is 65.6 inches. About twice the normal maximum snowpack was encountered. The snowpack started building in October with heaviest monthly amounts occurring in December and January. The peak water equivalent was reached on May 2 and meltout was completed by July 22.

The first data received from the profiling gage on January 3, 1972 indicated the snowpack was approximately 148 inches deep (Fig. 4). The bottom 40 inches had densities generally between 40 and 50 percent. The density then decreased to 18% at 70 inches and then increased to 34% at 88

inches. There was a general decrease in density from this point to 15% at 145 inches. A thin ice layer occurred at the surface. It was 2 inches thick and had a density of 40%. Two other higher density layers were noted as follows:

At 104 inches snow depth - 30 percent

At 122 inches snow depth - 30 percent

A possible explanation of the low density area at 70 inches of depth is provided by an analysis of the following data from Government Camp, Oregon, located 1½ miles southwest of the test site at the 3900' elevation, for December 1 through 10, 1971[1/]:

Date	Snow Depth	Maximum Temp ^{o}F	Precip. (Inches)	*Temperature ^{o}F Mt. Hood Test Site
Dec. 1	21	37		32
2	20	33	0.3	28
3	26	33	1.0	28
4	36	30	1.9	25
5	32	40	2.4	35
6	36	40	0.5	35
7	36	27		22
8	36	25	2.8	20
9	38	41	1.2	36
10	55	26	0.4	21

*Est. using 3^{o}/1,000' elevation lapse rate.

The low density area was probably formed during a period such as Dec. 3 through 7 or Dec. 8, 9, and 10, where snow was deposited during cold temperatures followed by a brief warm period with some melt and perhaps rain and then cold freezing temperatures with more snow. The warm melt period

and then subsequent cold temperatures formed the protective ice or dense snow layer above the cold dry snow.

Storms during January increased the snowpack to 220 inches depth by February 4 (Fig. 5). The low density layer previously centered at 70 inches on January 3 had now moved down to 60 inches. The high density layers were now located as follows:

92 inches snow depth - 40%

106 inches snow depth - 36%

120 inches snow depth - 40%

The high density layer at 120 inches depth was the surface ice layer noted previously on January 3. Additional high density layers occurred at 132 inches--35%, at 166 inches--40% and at 174 inches--41%. From 180 inches to the surface the general density was 20--25%.

A significant rain on snow event occurred during the last part of January that caused flooding and heavy streamflow in Oregon. Data was not collected during this period due to the one and only breakdown of the gage.

By mid-February the lower two-thirds of the pack was becoming stabilized. All major features maintained their identity with slight changes in location and density due to compaction and settling.

Some new higher density layers formed from new snow, especially in April (Fig. 6). Changes in density from settling and compaction were generally restricted to the upper pack during the spring months as the lower pack was well stabilized by this time. This is illustrated by the low density area that existed at 70 inches on January 3, at 60 inches on February 4, and was located at 52 inches by May 30 (Fig. 7).

The upper pack appeared stabilized by May 1 and a general water depletion began by mid-May. Individual features of the pack disappeared only when they were removed by melt.

In summary it may be said that:

1. Individual features of high or low density developed rapidly in deposits of new snow and maintained their identity through the rest of the snow season.
2. The lower two-thirds of the snowpack was fairly well stabilized by mid-February.
3. The upper one-third of the pack became stabilized around May 1.
4. General water depletion began in mid-May although the pack was discharging water prior to this, as indicated later in this report in a comparison of pillow and gage data.
5. It is unknown why the low density area at 52 inches on May 30 never achieved the densities of the heavier layers. It did not accept as much melt although melt could and did percolate through it. Additional operation of the gage may provide this information.

The water equivalent of the snowpack was compared to an 8-foot rubber snow pillow located approximately 12 feet to the west of the gage. Comparisons were also made to samples taken next to the gage with the Federal snow sampler and to water equivalents measured at the nearby Phlox Point snow course. These results are shown in Table 1.

TABLE 1

SNOW WATER EQUIVALENTS - Inches

Date	Isotopic Gage	8' Pillow & Manometer	Federal Sampler Next to Gage	Phlox Pt. Snow Course
12/22				45.1
1/3	43.5	41.8		
1/10	48.1	48.5		
1/13	56.5	57.0		
2/4	72.6	73.8		82.4
2/11	72.0	75.4		
2/15	77.2	80.0		
2/16	78.8	82.0		
2/18			92.0	
2/23	79.7	87.0		
2/28	80.5	97.7		
2/29	82.8	98.0		93.5
3/3	84.5	101.5		
3/10	85.4	Manometer shutoff W.Eq. exceeded Manometer height	103.0	
3/24	86.8			101.4
4/28	94.2			113.0
5/9	93.0		110.7	
5/30	71.1			82.1
6/5	61.7	97.3		

The isotopic gage and 8-foot rubber pillow compare very closely until February 23. This variance increased to a difference of 35.6 inches of water on June 5, with the 8-foot pillow recording the highest water equivalent.

In comparing the isotopic gage readings to samples taken with the Federal sampler near the gage and at the snow course, it can be seen that here the gage also reads less water equivalent. The snow course measurements were 13 to 20% higher and samples adjacent to the gage were 17 to 21% higher than the isotopic gage. The Federal sampler has been shown to over-measure 7 to 17% [2]. This would explain most of the variance which was found between the gage and Federal sampler.

CONCLUSIONS

1. Analysis of this years data indicates the isotopic gage satisfactorily measured the water equivalent of the snowpack which occurred between the source and detector tubes.

2. A percolation delay may have occurred on the 8-foot pillow during the melting of the very deep snowpack which accumulated on Mt. Hood. It possibly was due to melt water having to move horizontally off the pillow before more melt could percolate through from above. This ponding or hydrostatic head of melt water would have caused a higher than actual water equivalent as the season progressed and explain the large variance with the profiling gage by June 5.

3. Slight drifting was observed around the gage at various times during the winter. This was due, principally, to a wooden antenna tower which was close to the gage. It will be removed before further testing occurs. Some drifting may have been caused by the brace poles (Photo 3).

4. Cupping caused by radiation or heat conduction around the source and detector tubes was observed starting the last part of May. These cups or cones grew progressively larger as the meltout occurred and by June 17 were quite large. Some means of insulating the source and detector tubes will be found before further testing occurs (Photo 4).

5. Testing should be done through a full winter's season. This will give data for an entire period of snow accumulation and meltout.

6. Snow pillows with a gravel filter and without should be operated along with the gage to see if hydrostatic head does occur on the pillows and to compare shallow snowpack pillow readings with the profiling gage.

7. Precipitation and air temperature readings should be gathered during further testing of the gage to aid in analysis of the data.

8. Some means of transmitting information from the profiling gage via radio telemetry should be developed in the future for faster and better streamflow forecasting purposes.

9. Preliminary analysis indicates there is an operational use and need for the profiling gage. It is estimated that 3 to 5 gages will eventually be used in the Cascades and Coast range of Oregon.

PHOTO 1

Gordon Nikolaus, electronic technician, and Howard Vance, assistant snow survey supervisor, SCS, Oregon, installing the source and detector tubes.

SCS PHOTO 7-3222-6

PHOTO 2

Installing gas line in 12 feet of snow, December 1971.

SCS PHOTO 7-3222-7

PHOTO 3

Wooden antenna tower which caused slight drifting at various times around the isotopic gage.

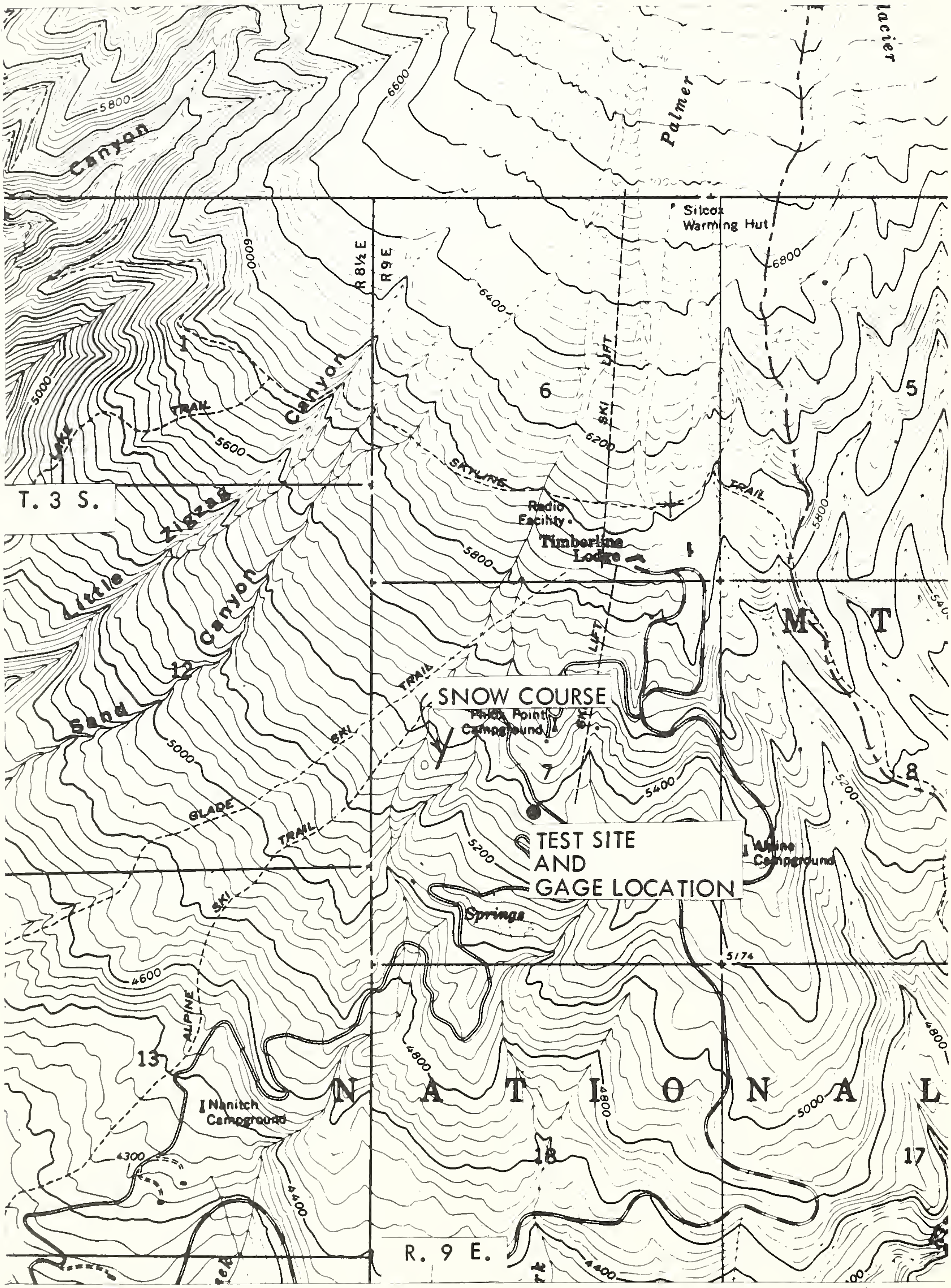
SCS PHOTO 7-3345-16

PHOTO 4

Sun cones observed at the isotopic gage on June 17, 1972. The cone around the source tube was 5 inches across the top and 6 inches deep. The cone around the detector tube was 22 inches across the top and 14 inches deep.

SCS PHOTO 7-3345-12

FIGURE I


SNOW COURSE
TEST SITE
AND
GAGE LOCATION
Timberline Lodge
Radio Facility
Silcox Warming Hut
Phlox Point Campground
Alpine Campground
Nanitch Campground
Springs
Palmer
Little Zigzag Canyon
Sand Canyon
Canyon
SKYLINE TRAIL
SKI LIFT
GLADE SKI TRAIL
ALPINE
T. 3 S.
R. 9 E.
R 8½ E
R 9 E
M T
N A T I O N A L
1
5
6
7
8
12
13
17
18
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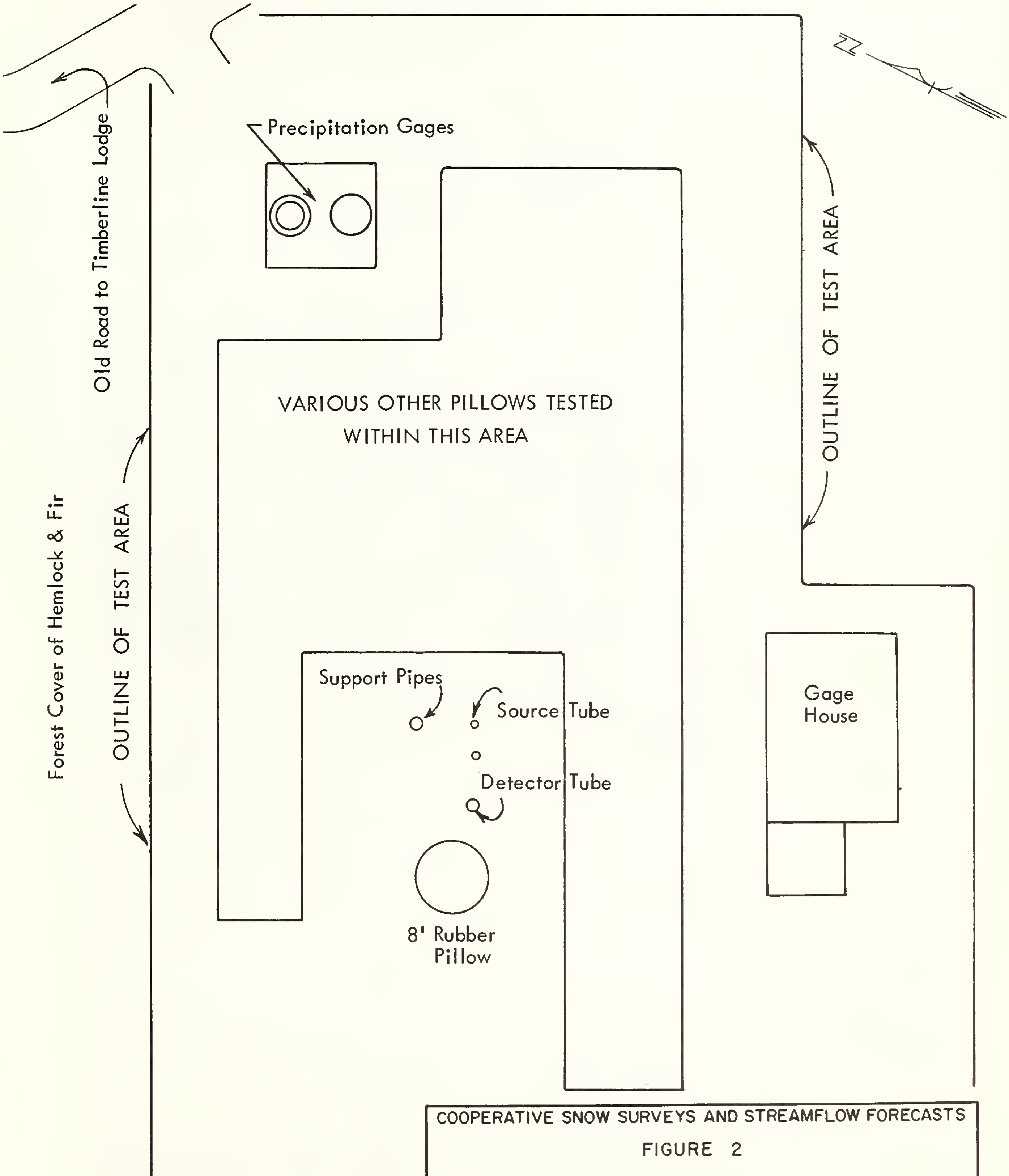


COOPERATIVE SNOW SURVEYS AND STREAMFLOW FORECASTS

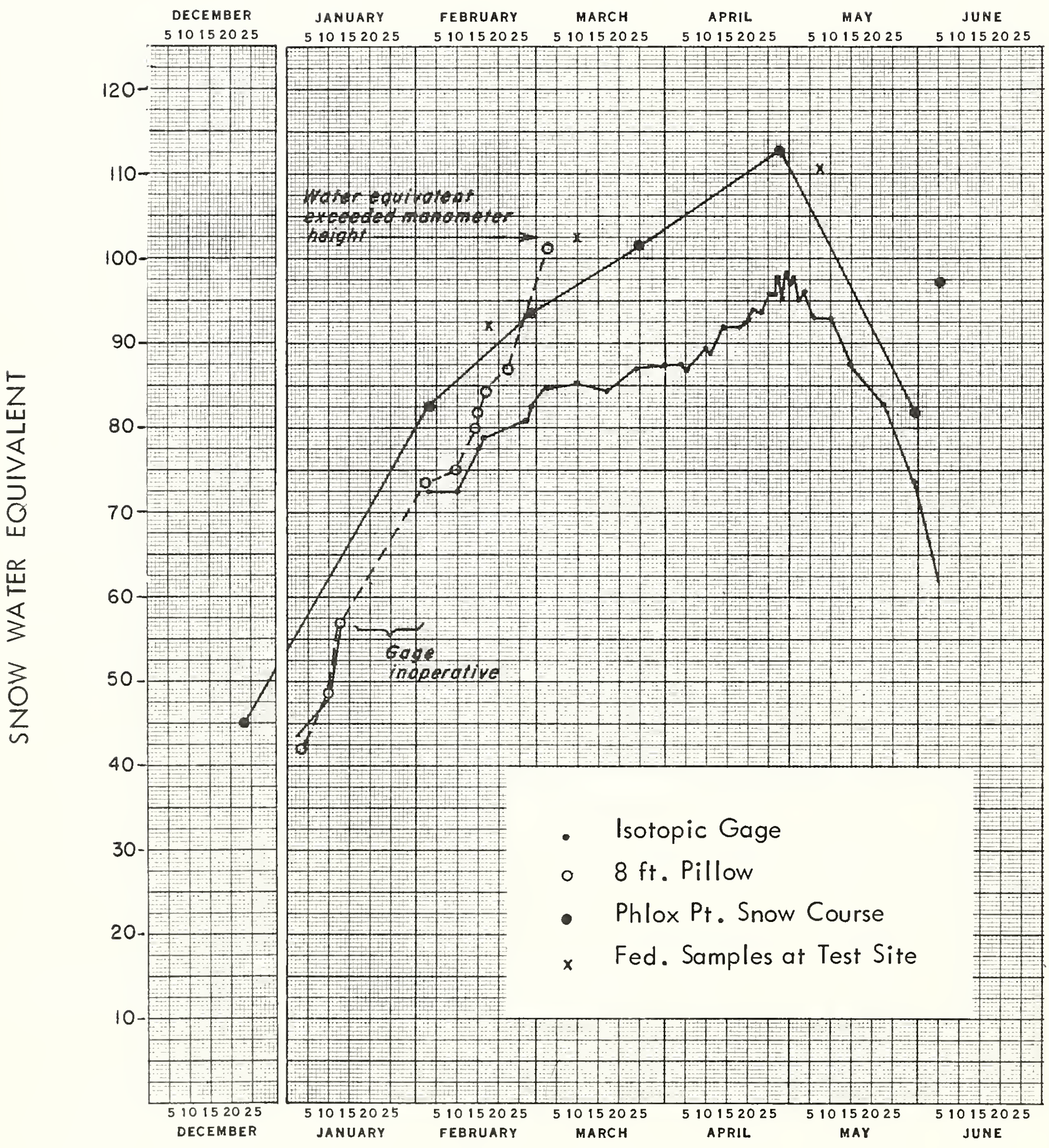
FIGURE 2

Mt. Hood Test Site

COURSE NO. SEC. 7 T. 3 S. R. 9 E.
ELEVATION 5555' SAMPLES INTERVAL

FIGURE 3

SNOW WATER EQUIVALENT
1971-1972 SEASON
MT. HOOD, OREGON
TEST SITE



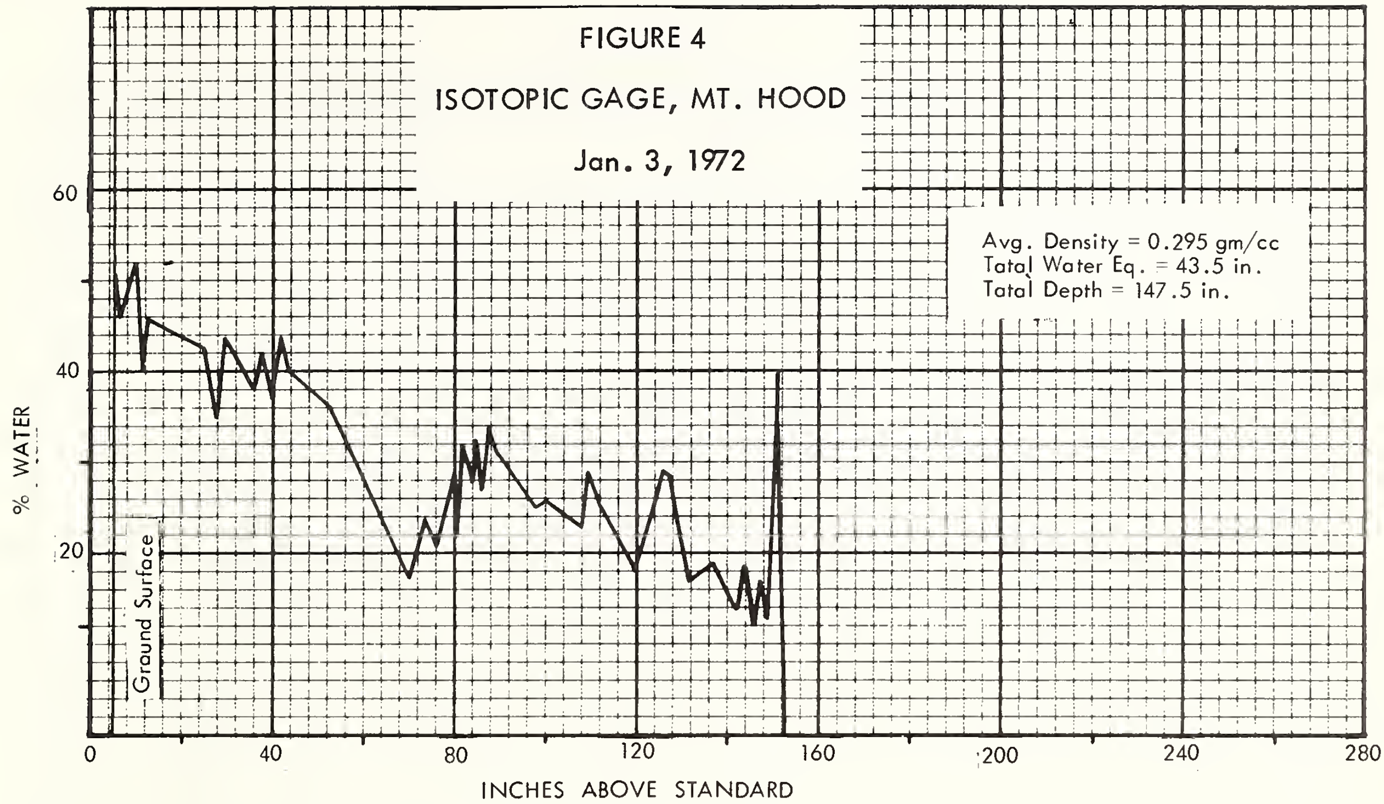


FIGURE 4
ISOTOPIC GAGE, MT. HOOD
Jan. 3, 1972
Avg. Density = 0.295 gm/cc
Total Water Eq. = 43.5 in.
Total Depth = 147.5 in.
60
40
20
% WATER
Ground Surface
0
40
80
120
160
200
240
280
INCHES ABOVE STANDARD

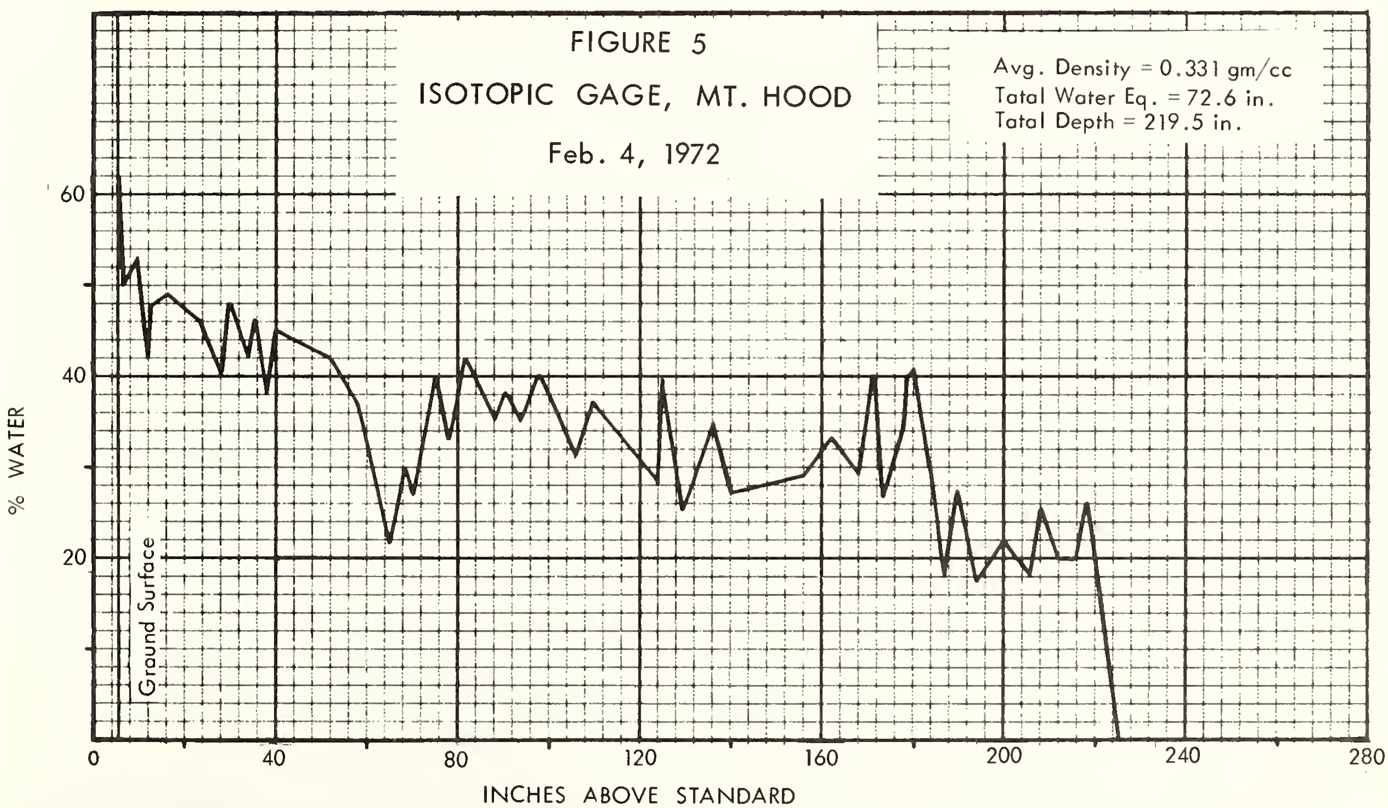


FIGURE 5
ISOTOPIC GAGE, MT. HOOD
Feb. 4, 1972
Avg. Density = 0.331 gm/cc
Total Water Eq. = 72.6 in.
Total Depth = 219.5 in.
60
40
20
% WATER
Ground Surface
0
40
80
120
160
200
240
280
INCHES ABOVE STANDARD

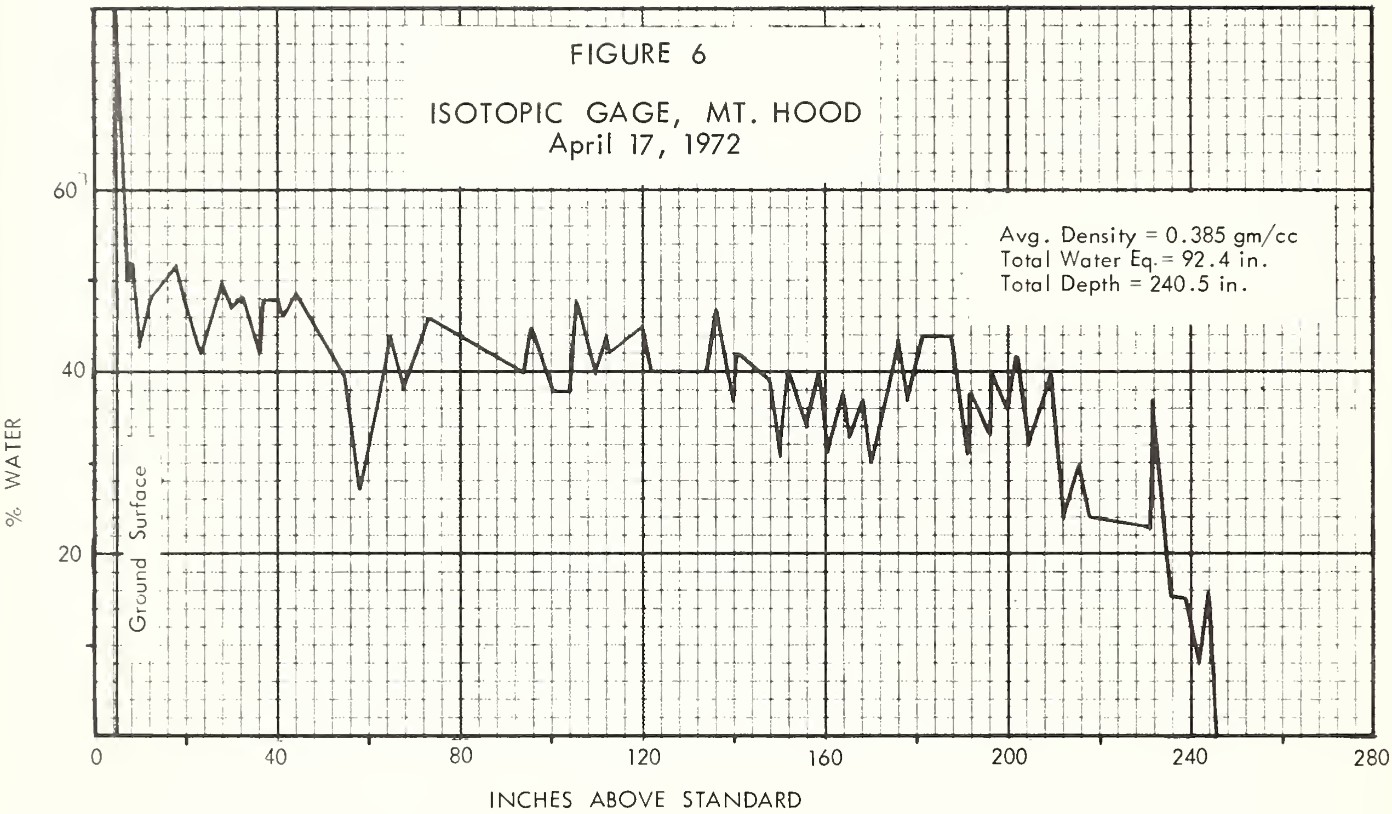


FIGURE 6
ISOTOPIC GAGE, MT. HOOD
April 17, 1972
Avg. Density = 0.385 gm/cc
Total Water Eq. = 92.4 in.
Total Depth = 240.5 in.
% WATER
Ground Surface
60
40
20
0
40
80
120
160
200
240
280
INCHES ABOVE STANDARD

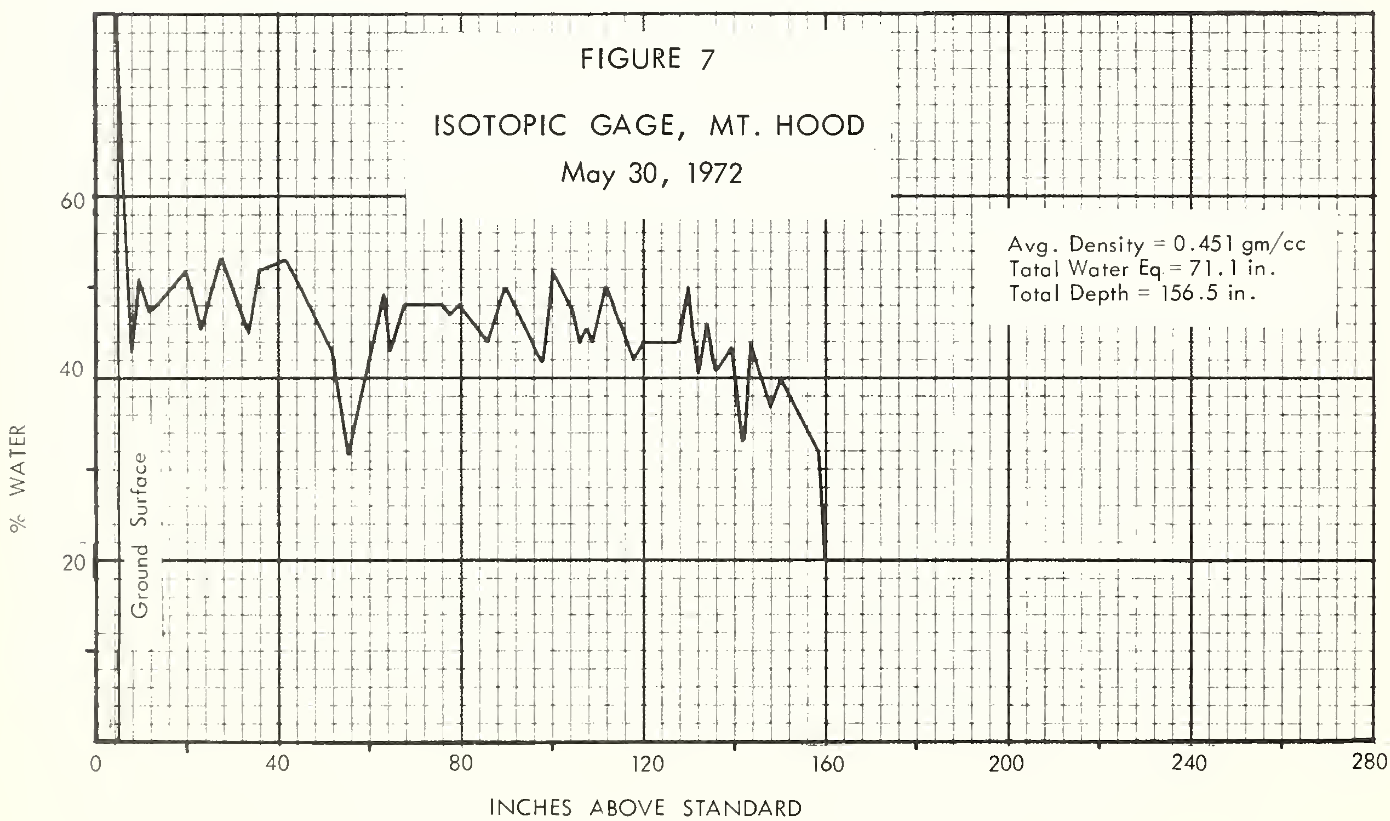


FIGURE 7
ISOTOPIC GAGE, MT. HOOD
May 30, 1972
Avg. Density = 0.451 gm/cc
Total Water Eq. = 71.1 in.
Total Depth = 156.5 in.
% WATER
Ground Surface
60
40
20
0
40
80
120
160
200
240
280
INCHES ABOVE STANDARD

BIBLIOGRAPHY

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2/. CRREL Technical Report 163. Accuracy of Field Snow Surveys, Western United States Including Alaska by Work, Stockwell, Freeman and Beaumont, August 1965.

FEDERAL - STATE - PRIVATE

COOPERATIVE SNOW SURVEYS

Furnishes the basic data
necessary for forecasting
water supply for irrigation,
domestic and municipal water
supply, hydro-electric power
generation, navigation,
mining and industry

*"The Conservation of Water begins
with the Snow Survey"*